Analysis of engine performance and emission characteristics of diesel engine using water injection in intake manifold and EGR

Paras.B.Oza[1] Mehul.K.Modh[2]

[1]Student [2] Professor
Mechanical Engineering Department
LCIT,Bhandu

***Abstract*-Diesel engines exhausting gaseous emission and particulate matter have long been regarded as one of the major air pollution sources, particularly in metropolitan areas, and have been a source of serious public concern for a long time. There has been numerous research in the field of reduction of these pollutants since diesel engines came to major use. Major emissions from a diesel engine are NOx, SOx, CO. and particulate matter (PM).amongst these pollutants CO and SOx and some quantity of particulate matters are reduced by some after treatment methods, outside the engine, in the catalytic converter etc. unlike these NOx can't be oxidized to get some clean product [6].**

In this paper combine effect of water injection and exhaust gas recirculation is used to experimentally check the effect of that in performance and emission characteristics. The main reason for the increment of Nox is short ignition delay and high flame temperature. As water injection system controls the NOx because it increase the ignition delay and lowering flame temperature of the working fluid in the combustion chamber. Exhaust gas recirculation system also lowers the flame temperature in the combustion chamber and reduce the Nox emission [4]. Present experimental study will be carrying out in a single cylinder, water cooled four stroke diesel engine to experimentally evaluate the performance and emissions for different Water Injection rates and EGR
Three different rates (6 ml/min,9 ml/min,12 ml/min) of water will inject in engine and at the same time the engine run with fixed percentage of EGR to check the combine effect of both on different loading conditions. The results will matches against that of diesel and comparison graphs will be plotted to see what are the advantages and disadvantages of using the combine effect of WIS and EGR.

I.INTRODUCTION

Diesel engines are used in a wide variety of applications including transportation of men and materials, construction equipment, power generation and many farming process because of their reliability, durability, and power and fuel efficiency. However, diesel engines have also been recognized by its polluting emissions affecting the air quality. From diesel engines nitrogen oxides (NOx), particulate matters (PM), sulphur oxides (SOx), unburned hydrocarbon (HC), black smoke, carbon monoxide (CO), and carbon dioxide (CO2) are the key pollutants.[3] Oxides of Nitrogen (NOx) from the diesel combustion are highly dangerous. Among these CO,Sox and some quantity of PMare reduced by some after treatment methods ,outside the engine in catalytic convertor etc .unlike theseNOx can't be oxidize to get some clean.

Increasing market demand and stringent government regulations are pushing engine manufacturers to develop low emission diesel engines. Most of the problems have been resolved with the exception of emission levels of NOx and PM. Formation of NOx and PM are highly temperature dependent and are contradictory to each other. Attempt to reduce one will cause an increase in the other. One way to simultaneously reduce NOx and PM emissions significantly is to introduce water into the combustion chamber of the engine via intake manifold.The main mechanism causing the reduction in NOx emissions seems to be the decrease in temperature of the combustion products as a result of vaporization of the liquid water and consequent dilution of the gas phase species.

EGR is also an effective technique to reduce NOx emissions.EGR involves routing a fraction of engine exhaust gas into the intake manifold where it mixes with the incoming fresh air before being taken in to cylinder.When a part of this exhaust gas is recirculated to the cylinder, it acts as diluent to the combustion mixture. It also reduces the O2 concentration in the combustion chamber.Because of high specific heat of EGR, heat capacity of the intake charge upsurges, thus decreasing the temperature rise for thesame heat release in the combustion chamber.

Here in this paper the combine effect of water injection with EGR is described to show that how the combine effect is reduce the NOx percentage in emission.

II.METHOD AND MATERIAL

Three methods for introducing water into the combustion zone are as below [5].

(i) Direct injection into the engine cylinder through separate injectors (DWSI)

(ii) Fumigating the water into the engine intake air (FWIA)

(iii) Diesel/Water emulsions (DWE)

Upper all the methods proposed to introduce water into the combustion chamber, but fumigation means introduction of water into the engine intake manifold with intake air most appropriate, because they do not require any modification to engine cylinder as well as the special production of fuel like emulsion can be ignored.

The various rates of Water injection in intake manifold with fixed percentage of EGR to be used are as follows:
1. Water injection (6 ml/min) and EGR (40 %)
2.Water injection (9 ml/min) and EGR (40 %)
3.Water injection (12 ml/min) and EGR (40 %)

III.EXPERIMENTAL SETUP DESCRIPTION

A single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power is considered for the experimentation.

Experimental Setup of Diesel Engine

Fig 1.-Experimental Setup of Diesel Engine

Engine Specification

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 kW
Rated speed	1500 rpm
Capacity	553CC

Table1. Engine Specification

Parameters required for prediction:-
Input Parameters:
1. Water injection rates (ml/min)
2. EGR percentage (%)
3.Engine Load (kg)
Output Parameters:
1. BSFC (Brake Specific Fuel Consumption)
2. Mechanical Efficiency
3. BTE (Brake Thermal Efficiency)
4. ITE (Indicated Thermal Efficiency)
5. CO (Carbone monoxide)
6. NO_X (Nitrogen Oxide)

IV. CALCULATION OF PARAMETERS

Using Diesel

Sr.No	Load (kg)	F.C (Kg/hr)	B.P (kw)	B.S.F.C (kg/kw-hr)	F.P (kw)	I.P (kw)	M.E (η m%)	B.T.E (η bth%)	I.T.E (η ith%)	CO%	NO_X (ppm)
1	2	0.47	0.43	1.09	1.8	2.23	19.28	7.74	40.19	0.06	107
2	4	0.60	0.87	0.68	1.8	2.67	32.58	12.28	37.69	0.06	140
3	6	0.67	1.3	0.51	1.8	3.1	41.93	16.43	39.19	0.05	181
4	8	0.84	1.73	0.48	1.8	3.53	49	17.44	35.59	0.06	309

Using Diesel + 6 ml/min WI + 40% EGR

Sr.No	Load (kg)	F.C (Kg/hr)	B.P (kw)	B.S.F.C (kg/kw-hr)	F.P (kw)	I.P (kw)	M.E (η m%)	B.T.E (η bth%)	I.T.E (η ith%)	CO%	NO_X (ppm)
1	2	0.47	0.43	1.13	1.5	1.75	25	9	34.26	0.06	101
2	4	0.64	0.87	0.73	1.5	2.18	42	14.50	35.67	0.06	138
3	6	0.76	1.3	0.58	1.5	2.8	52	17.73	34.47	0.06	182
4	8	0.93	1.73	0.54	1.5	3.05	58.09	18.27	33.01	0.05	293

Using Diesel + 9 ml/min WI + 40% EGR

Sr.No	Load (kg)	F.C (Kg/hr)	B.P (kw)	B.S.F.C (kg/kw-hr)	F.P (kw)	I.P (kw)	M.E (η m%)	B.T.E (η bth%)	I.T.E (η ith%)	CO%	NO_X (ppm)
1	2	0.50	0.43	1.13	1.6	1.93	22.27	9.84	43.35	0.06	100
2	4	0.60	0.87	0.70	1.6	2.37	38.70	16.95	52.07	0.05	132
3	6	0.84	1.3	0.64	1.6	2.9	46.42	17.44	37.58	0.05	175
4	8	0.90	1.73	0.52	1.6	3.23	54.56	22.15	38.50	0.05	285

Using Diesel + 12 ml/min WI + 40% EGR

Sr.No	Load (kg)	F.C (Kg/hr)	B.P (kw)	B.S.F.C (kg/kw-hr)	F.P (kw)	I.P (kw)	M.E (η m%)	B.T.E (η bth%)	I.T.E (η ith%)	CO%	NO_X (ppm)
1	2	0.45	0.43	1.08	1.15	1.58	28	12	44.49	0.05	85
2	4	0.58	0.87	0.65	1.15	2	44	19.91	43.45	0.05	105
3	6	0.74	1.3	0.55	1.15	2.47	54.49	23.84	44.69	0.04	140
4	8	0.91	1.73	0.52	1.15	2.80	61.62	24.11	40.01	0.04	245

V. CONCLUSION

In this study of water injection with EGRinvestigated the effect On the Diesel engine performance and exhaust gases emissions. The water injection with6 ml/min, 9 ml/min, 12 ml/min with 40% EGR is introduced to in four stroke single cylinder diesel engine. The Engine operate at various load condition. The results indicated that the addition of water to the engine in the form of fumigation improves combustion efficiency. The engine torque, power and brake thermal efficiency increase as the water rates by volume in the emulsion increases. The average increase in the brake thermal efficiency for 12 ml/min water injection is approximately 5% over the use of diesel for the engine speed ranges studied. The particulate matter, CO and NOx emissions decrease as the water injection rate reaches 12 ml/min. So that, the benefits of injecting water in engine, results in substantial reductions in nitrogen oxides and particulates.

VI. ACKNOWLEDGMENT

I am humbly expressing thanks to my respected guide Prof.Mehul.K.Modh, Assistant Professor, Department of Mechanical Engineering, LaljibhaiChaturbhai Institute of Technology, Bhandu, for his valuable time and constant help given to me.

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